genus *Phenacodus*, and that without this annectant form it would have been almost impossible to say that the Puerco mammals were Ungulates at all, since their feet are more like those of the plantigrade Carnivores. The details of how the foot of the generalized primitive type has become gradually modified into the numerous modifications exhibited by the Ungulates of the present day, are far too technical and complicated to be even touched upon in these pages, and we must therefore refer the reader desirous of entering upon this difficult branch of study to the memoir itself. We may, however, mention that the primitive type of foot (Fig. 2) is characterized by the component bones of the two horizontal rows of the wrist and ankle being placed vertically one above another, over the axes of the digits they respectively support; while in the specialized types (Fig. 3) these bones mutually overlap and interlock, so as to totally obliterate the original vertical lines of division coinciding with the intervals between the individual digits. The nearest approach to the primitive type now remaining, is found in the elephant and the hyrax; but the elephant and its ally the mastodon (Fig. 2) are peculiar in that the lunar bone of the wrist has become extended towards the outer side so as to rest upon the trapezoid.

In conclusion, we may observe that a memoir like the present marks a distinct advance in our knowledge, not only of the mammals of the Upper Eocene of North America, but also in respect to several points in connection with the phylogeny of the Ungulates, and of the relationship of the extinct Old World representatives of that order to those of the new. We offer our congratulations to the authors, and look forward to seeing equally good work on the mammals of other horizons of the Tertiaries of the United States.

R. L.

EARTHWORMS.

THE Colonial Office can hardly render a greater assistance to science, than by publishing such reports from our distant possessions as that contained in the October number of the *Kew Bulletin*, from Mr. Alvan Millson, Assistant Colonial Secretary at Lagos, who has also acted as a Special Commissioner to the interior, and who has made good use of his opportunities in observing Nature in those remote parts.

The report in question is contained in a despatch from Sir Alfred Maloney to Lord Knutsford, dated June 11, 1890, and we propose to give a short account of its contents.

In Yoruba Land, after passing the fringe of forest, which skirts the lagoons to the eastward of Lagos for some 50 miles inland, a vast tract of open country is reached, extending as far as the valley of the Niger and the Houssa States beyond. The only difference between these grass lands and the forest fringing the lagoons appears to be that "for many generations the farmers of Yoruba have with axe and fire destroyed the growing trees, and robbed the soil of its original covering, leaving nothing but a rank growth of tall and tangled grass to take its place." This is apparently unfavourable to the growth of deep-rooting trees, but shows a truly surprising surface-fertility, when subjected to cultivation; and as the Yoruba people are cut off from the coast by the tribes inhabiting the forest belt, and are entirely dependent on the soil for food and clothing, it has to support a considerable population.

The soil appears to consist of a sandy loam derived from the igneous rocks, ironstone or quartz conglomerate, which form the bed rock, the soil increasing in fertility where the harder strata give place to more friable micaceous rocks, but even where the soil is not over a foot in depth, the fertility is truly astonishing. Crops in Yoruba are not only of unusual excellence, but the surface soil shows a marvellous recuperative power, even when compared with that of favoured lands in other portions of the tropics.

In this district, after a very simple tillage with the hoe only, the following rotation of crops is raised. In the first year a crop of yams and Indian corn is planted, and a second crop of maize and beans in the autumn; the same in the second year; while in the third year both crops are maize and beans. No manure of any kind is used, nor any tool more powerful than the hoe; and then for two or three years the land lies fallow, after which it is ready for a similar rotation, and so on. A crop of Guinea corn, cotton, indigo, tobacco, and sweet potatoes is also in some places gathered.

In spite of the exhaustive system of cultivation pursued, the crops show no sign of falling off, and such is the inexhaustible fertility of this belt, that maize sells for 4½*d.* and sweet potatoes at 1*d.* per 70 pound load, and other products in proportion, even in large towns like Ibadau, said to have 150,000 inhabitants.

Mr. Millson considers that the fertility cannot be caused by termites, as described by Drummond in "Tropical Africa," as the ant-hills of the Yoruba land are exceptionally small and widely scattered; and visiting the country only in the wet season, it would appear impossible to account for the unusual fertility. In the dry season the mystery is at once solved, in a very simple and, Mr. Millson considers, in a most unexpected manner; although, taking into account the universal presence of the earthworm, both in temperate and tropical climates, we think there is little reason for surprise; but we do not remember to have heard of a more marked instance of the importance of small agencies in effecting great results.

Mr. Millson continues:—"The whole surface of the ground, among the grass, is seen to be covered by serried ranks of cylindrical worm-casts, varying from a quarter of an inch to 3 inches, and existing in astonishing numbers. For scores of miles they cover the land, closely packed, upright, and burnt by the sun into rigid rolls of hardened clay, which stand until the rain breaks them down into a fine powder. . . . On digging down, the soil is found to be drilled in all directions by countless multitudes of worm-drills; while from 13 inches to 2 feet in depth the worms are found in great numbers in the moist subsoil."

Mr. Millson estimates that the worm-casts, in one season, average over 5 pounds per square foot of soil; and at this estimate, which he considers very moderate, the annual result of the work done by the earthworms of Yoruba gives a total of not less than 62,233 tons of subsoil brought to the surface in each square mile of cultivated land every year. "This work goes on unceasingly year after year, and to the untiring labours of its earthworms this part of West Africa owes the livelihood of its people. Where the worms do not work, the Yoruba knows that it is useless to make his farm."

Mr. Millson estimates that every particle of earth in each ton of soil, to the depth of 2 feet, is brought to the surface once in twenty-seven years, which gives an average of 0·88 inch per annum, or four times as much as Darwin estimated ("Earthworms," p. 130) to be the case in the experiments tried at Maer Hall; but on the Nilgiries, worm-casts are found to average 3 ounces each, the largest weighing 4¼ ounces (*ibid.*, p. 129). We have, therefore, little doubt that Mr. Millson's estimate of the movement of soil is quite probable.

Mr. Millson considers that, most probably, the comparative freedom of this part of West Africa from dangerous malarial fevers is due, in part at least, to the work of the earthworms in ventilating and constantly bringing to the surface the soil in which the malarial germs live and breed. Darwin (*ibid.*, p. 239) remarked that the disappearance of organic matter from mould was probably much aided by its being brought again and again to the surface in

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the castings of worms, and this would account for the absence of malarial fevers.

The worms sent home by Mr. Millson have been submitted to Mr. F. E. Beddard, who reports that they belong to a probably new species of the genus *Siphonogaster*.

We trust that Mr. Millson will continue to send home further accounts of his valuable observations, and that the example he has set will be followed by others stationed in our colonies.
S. N. C.

MUSEUMS FOR PUBLIC SCHOOLS.

All teachers, I have no doubt, have experienced the refreshing interest that boys and girls take in objects of natural history. And not in natural history merely, for whenever the lesson, no matter what it is about, admits of being illustrated by specimens, then the presence of these specimens gives a point to the description and produces an effect that otherwise would be wanting. Take your young audience in imagination into the country or to the seaside, and show the nest and bird, insect, plant, seaweed, or crab you are describing, and you know you can sustain their attention throughout. It is equally certain, too, that, in describing the characteristics of any particular place, it is desirable to be able to indicate by something more than the bare statement what is meant by "solan-geese and other sea-fowl," and such expressions. How vague often are the ideas produced by the words ruby, marble, granite, isinglass, and other "articles of produce," even though well described, when the actual article itself is bound to implant the nature of the object in the pupil's mind, and the description at the same time. How much could be taught in a very agreeable way, moreover, with a series of specimens exhibiting the manufacture of certain important fabrics from the raw material, and especially those that are made in the immediate district of the school.

It will be generally admitted, I think, that schools should be provided with the means of giving such instruction: the difficulty is, how can it be done? Suggestions have been made on several occasions that the specimens in our public museums should be made available for the purpose. Dr. James Colville, in a paper on "Public Museums as Aids in Teaching,"[1] has pointed out that he is allowed to draw upon the Glasgow Museum for specimens. In Liverpool, alone, however, as far as I know, is the circulation of museum objects carried out in a satisfactory and systematic manner. A good account of the method is given in a pamphlet on a "Proposed Circulating Museum for Schools and other Educational Purposes," by the Rev. Henry H. Higgins, published in 1884; and in the Report which was issued by Mr. Thomas J. Moore, the Curator, later in the same year. The Museum distributes a series of boxes of specimens, and these are removed from school to school at stated intervals.

In many districts, however, and especially where the public Museum is more or less remote, the system so generously inaugurated by the Liverpool Museum will not be found available. In some of our large provincial towns, indeed, where there is a Museum, such a scheme could not be carried out without a great extension of the work of the Museum, for which there is at present no provision. Where this is so, and alas, it is quite general, an attempt is made in many of our schools to gather together what must necessarily be a desultory and very limited collection. I am afraid that few schools, indeed, can show such a typical series of natural history specimens as that sketched by Prof. Flower in NATURE (vol. xli. p. 177).

Here, then, is a good work for the secondary schools which are now and again springing up all over the country. In each of these academies and high schools there is a science department, which, besides its chemical apparatus and the like, can boast, no doubt, of a number of objects gathered at random. And though these may be far more numerous than the specimens to be seen in the ordinary school in the next street, still, how far is the collection from being systematic and typical! The specimens are usually kept, moreover, in drawers, and at any rate with little attempt to display, arrange, or name them. But were the facilities for gathering specimens increased; were a room set apart and furnished with cases for their reception; were, in fact, the secondary school encouraged to get together a double series of objects—one for circulation in the surrounding district, and one for its own use—the benefits now being enjoyed in Liverpool might be extended to other towns without waiting for the public Museum to take the matter up. For each town, in this way, one or two reasonably typical collections, including actual specimens, models, and diagrams, would be provided; and the amount expended at present in individual endeavours would go far towards having this done with considerable completeness.

A good outline of what should be aimed at in such a museum is given in the article by Prof. W. H. Flower, cited above. He has also contributed a series of papers on "Methods," which will be found of the utmost service (NATURE, vol. xv. pp. 144, 184, 204); and it will be seen from these latter that it is quite possible to prepare a great portion of the museum in the school. Still, no better model could be copied than that provided at Liverpool, both as regards the choice of the specimens, and the method of circulating them. The pamphlets referred to above contain information on both points. I should only take the opportunity of recommending that which I have incidentally mentioned in the opening sentences, viz. the addition of important articles of commerce and manufacture.

With such a museum at the disposal of our schools, and provision made for its growth, and the display of a duplicate series of specimens in the secondary school itself, the results of our teaching would be far more real and lasting, and we might now and then touch a sympathetic chord, and awaken an interest having a life-long influence.
Alexr. Meek.

University College, Dundee.

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[1] Read before the Philosophical Society of Glasgow in 1888.

JAMES CROLL, F.R.S.

By the death of this well-known writer geological literature loses one of its most voluminous and able contributors. Though not in the proper sense of the word a geologist, he had made himself well acquainted with many geological problems, and first attracted notice more than five-and-twenty years ago by the brilliance and suggestiveness of his attempts to solve them. He was born in 1821 at Little Whitefield, in Perthshire, and after the usual brief schooling of a peasant's son he was apprenticed as a millwright in his native village. The employment allowed him leisure for reading, and he devoted himself with ardour to the study of philosophy and of physical science. At the age of twenty-four, however, the effects of an accident which he had met with in boyhood compelled him to seek a less laborious vocation, and eventually he became agent for an insurance company. These early years gave but little promise of the particular bent of his genius by which he would attain distinction. Eventually his general acquirements and the zeal with which he was known to devote his spare time to philosophical reading attracted the interest of the governing body of the Andersonian University and Museum in Glasgow, and in 1859 he was appointed keeper at that establishment. He had already found his way into print by publishing anonymously a

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